

CLAIMS

What is claimed is:

1. A method for providing dynamic gain control of an optical Raman amplifier in an optical communications link comprising an optical waveguide for transmitting optical signals on channels at different wavelengths, the optical Raman amplifier including at least a first optical pump source of a first pump wavelength and a second optical pump source of a second different wavelength, said pumps optically coupled to provide optical energy to the optical waveguide of sufficient pump powers to cause stimulated Raman scattering for amplifying optical signals, and a pump controller for controlling the pump powers of the at least first and second optical pumps in response to data from an optical signal detector, comprising the steps of:

a) characterizing a gain profile and gain level of the Raman amplifier when the channels of the communications link are fully loaded, over a wavelength spectrum at least as great as a desired transmission channel spectrum;

b) pre-establishing a set of pump power values and signal level values required to maintain the characterized gain profile and gain levels for a plurality of channel loading configurations for the first pump wavelength;

c) deriving a linear function from the set of pre-established values for the first pump wavelength;

d) pre-establishing a set of pump power values and signal level values required to maintain the characterized gain profile and gain levels for a plurality of channel loading configurations for the second pump wavelength;

e) deriving a linear function from the set of pre-established values for the second pump wavelength;

f) tapping a portion of an amplified signal;

g) detecting a total amplified signal power from the tapped portion of the amplified signal;

- h) calculating the required first and second pump powers to maintain the characterized gain profile and gain level as a unique solution from the linear functions; and
 - i) providing the calculated pump powers for the first and second pumps to a pump controller for comparing the calculated pump powers to current pump powers and varying the pump powers if necessary.
2. The method as defined in claim 1, wherein the set of pump power values and signal level values required to maintain the characterized gain profile and gain levels for a plurality of channel loading configurations for the first and second pump wavelengths are pre-established by integrated measurement devices within the amplifier.
 3. The method as defined in claim 1, wherein the set of pump power values and signal level values required to maintain the characterized gain profile and gain levels for a plurality of channel loading configurations for the first and second pump wavelengths are measured by imposing a signal modulation on each pump power and measuring a resulting modulation amplitude on a probe signal channel.
 4. The method as defined in claim 1, wherein the set of pump power values and signal level values required to maintain the characterized gain profile and gain levels for a plurality of channel loading configurations for the first and second pump wavelengths are measured by monitoring a back reflected amplified spontaneous emission power as a function of pump power for each of the first and second pump wavelengths.
 5. The method as defined in claim 1, wherein tapping a portion of an amplified signal further includes dividing the tapped amplified signal into a plurality of wavelength bands, and subsequently detecting a total amplified signal power of each wavelength band.
 6. The method as defined in claim 5 wherein detecting a total amplified signal power from the tapped portion of the amplified signal, and calculating the required first and second pump powers to maintain the characterized gain profile and gain level as a unique solution from the linear functions is based on a weighted sum of the plurality of tapped amplified wavelength bands.
 7. An optical Raman amplifier for providing dynamic gain control of an amplified signal comprising

an optical waveguide for transmitting a plurality of optical signals on channels at different wavelengths;

at least a first and a second Raman pump source having different wavelengths optically coupled to the optical waveguide for providing variable optical pump power to produce Raman gain for the optical signals;

an optical power monitor for measuring optical power of the amplified signals for monitoring changes in channel loading;

a pump controller for comparing the optical power of the amplified signal to a first and a second stored linear function, said linear functions correlating each of a first and second Raman pump power levels to total signal power in accordance with a pre-established Raman gain profile and gain level of the Raman amplifier in a fully loaded channel configuration, and for modifying the pump power of the first or second pump sources to correspond to a value of the first or second stored linear function in response to changes in channel loading.

8. The optical Raman amplifier defined in claim 7, wherein the first and second stored linear functions are obtained by pre-establishing a set of pump power values and signal level values required to maintain the pre-established gain profile and gain levels for a plurality of channel loading configurations for each of the first and the second pump wavelengths, and deriving a linear function from the set of pre-established values for the first and second pump wavelengths.

9. The optical Raman amplifier defined in claim 7, wherein the optical power monitor comprises a photodiode.

10. The optical Raman amplifier defined in claim 7, wherein the optical power monitor comprises a plurality of photodiodes and associated means for directing only a wavelength band portion of the amplified signal to each of the plurality of photodiodes.

11. The optical Raman amplifier defined in claim 10, wherein the means for directing only a wavelength band portion of the amplified signal comprise a plurality of wavelength filters for directing wavelength band portions of the amplified signal to associated photodiodes of the plurality of photodiodes.

12. The optical Raman amplifier defined in claim 11, wherein the pump controller for comparing the optical power of the amplified signal to a first and a second stored linear function, compares a weighted average of the optical power of the amplified signal from the plurality of photodiodes.

13. The optical Raman amplifier defined in claim 7, wherein the amplifier is a distributed Raman amplifier.

14. The optical Raman amplifier defined in claim 7, wherein the amplifier is a discrete Raman amplifier.

15. The optical Raman amplifier defined in claim 13, wherein the at least first and second Raman pump sources are optically coupled to the optical waveguide for providing counter-propagating pump energy.

16. An optical Raman amplifier for providing dynamic gain control of an amplified signal comprising

an optical waveguide for transmitting a plurality of optical signals on channels at different wavelengths;

at least a first and a second Raman pump source having different wavelengths optically coupled to the optical waveguide for providing variable optical pump power to produce Raman gain for the optical signals;

an optical power monitor for measuring optical power of the amplified signals for monitoring changes in channel loading;

a pump controller for comparing the optical power of the amplified signal to stored values correlating pump power levels of the first and second pump sources to total amplified signal power in accordance with a pre-established Raman gain profile and gain level of the Raman amplifier in a fully loaded channel configuration, and for modifying the pump power of the first or second pump sources to correspond to a stored value in response to changes in channel loading.